BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

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| In the Matter of | ) | |
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| | ) | |
| Creation of a Spectrum Sharing | ) | ET Docket No. 06-89 |
| Innovation Test-Bed | ) | |

## COMMENTS OF ARRAYCOMM LLC

ArrayComm LLC (hereinafter "ArrayComm") is pleased to submit the following comments in the above-entitled matter.

### Introduction

The Federal Communications Commission ("FCC") and the National Telecommunications and Information Administration ("NTIA") are soliciting comments to evaluate innovative methods for spectrum sharing to enable more intensive use of the radio spectrum for federal and non-federal users via a Spectrum Sharing Innovation Test-Bed ("Test-Bed"). ArrayComm lauds the Commission's Public Notice to consider a spectrum sharing innovation Test-Bed that could be used, inter alia, to demonstrate techniques for improving the effectiveness of spectrum use and to evaluate means for measuring spectral efficiency.

ArrayComm is particularly interested in this proceeding because it has long been dedicated to the improvement in the performance of wireless systems through the development and utilization of spectrally efficient technologies based upon multiple antenna signal processing (MAS including smart antennas, MIMO, and other multiple antenna solutions). Over the past several years, ArrayComm has filed comments and replies in a number of proceedings noting that MAS offers advantages in spectral efficiency, especially for high-speed data applications and public safety.[1]

[1] See, for example, ArrayComm's Comments and Reply Comments in ET Docket No. 00-221,15 FCC Rcd. 22657 (2000); WT Docket No. 02-08,67 FR , 7113 (2002),ET Docket No. 00-258,18 FCC Rcd 2223 (2003); see also, WT Docket No. 02-353 (2003)

Although the request for comment focuses upon the sharing of spectrum by federal and non-federal users, commenters are encouraged to file comments on related issues. The following comments are in this context.

## Historical Impact of Spectrum Sharing

The Commission is commended for recognizing the importance of spectrum sharing as a valuable tool in optimizing the value of the radio frequency spectrum in the public interest. Spectrum sharing is not a new concept. While the focus of this proceeding is on creating technology that will allow different licensing entities to share spectrum in a given geographic location, it is always necessary for two users to be physically separated in sharing situations. Thus, there is not a great deal of difference between the spectrum sharing envisioned in this proceeding and the geographic sharing that is inherent in existing deployments such as land-mobile, cellular telephony, and even broadcast radio. The real issue is eliminating, or mitigating interference between such users.

Of all the techniques that have been used to make the spectrum more valuable to the public since the commercialization of radio over 100 years ago, geographic spectrum sharing has been dominant. In fact, almost all of the improvement that has been made since the beginning of radio has been in the form of geographic sharing. Furthermore, the benefits of other techniques such as improved radio transmission protocols, increase in the useful frequency range, and compression techniques, have been virtually exhausted; we are approaching their theoretical limits. In contrast, we have only begun to exploit the potential benefits of geographic spectrum sharing.

Despite the huge improvements made in the past 100 years, the potential to further improve spectral efficiency, that is, to improve the traffic handling capacity of radio spectrum, has barely been tapped. The use of MAS technology in the coming years can contribute substantially to this goal. As a further benefit, this technology has been commercially proven, in contrast to the early experimental stage of technologies such as cognitive radio.

## An Example

Spectrum sharing, as envisioned in the request for comments, is available today using existing systems with relatively minor changes. Further, Mobile WiMAX and similar offerings will be available in the coming year that will also make such sharing possible.

An example of such sharing would involve giving both Federal and commercial users' access to a highly efficient broadband wireless system (such as those deployed in a number of countries today). All users would have access to data rates up to one MB/s or higher but the data rate available to each user would be programmable by

the carrier. Since all communications on the system is encrypted, there is privacy comparable to or better than exists in today's systems. Each user or category of users would be assigned a priority. Under normal traffic conditions, there is adequate capacity to provide a high quality of service to all users. When an emergency occurs, certain Federal users would receive priority such that a predetermined proportion of the entire system capacity would be available to them. If the emergency were sufficiently urgent, the entire system could be turned over to a discrete group of designated Federal users. For lesser emergencies, high priority users would get varying degrees of preference.

In the above example: 1) Sharing occurs in every sense of the word; 2) Spectral efficiency is very high because the type of system proposed uses the most advanced MAS technology and because it is specifically designed to support broadband data; 3) Very little development and no research is required to implement such a system; and 4) Such solutions are available now and many similar ones will be available in the near future.

## MAS Should Be Incorporate in the Spectrum Sharing Innovation Test-Bed.

MAS has been demonstrated to achieve improvements in spectral efficiency in existing personal communication systems. These systems are available in other parts of the world but not in the United States. Furthermore, proposed technologies, such as cognitive radio, will benefit from the use of MAS, and in fact, may require MAS. MAS can mitigate interference in shared-spectrum usage and thus result in increased spectrum efficiency.

## The Spectrum Sharing Innovation Test-Bed Can Objectively Measure Spectral Efficiency

An important element of any Test-Bed established by the FCC will be to create an objective measurement of spectral efficiency. Without such an agreed-upon standard measure of the effectiveness of spectrum use, the results of the Test-Bed will be less useful and more controversial. Improving the efficiency of spectrum usage will be an evolutionary process. Technical and economic performance targets as well as metrics that can be used to gauge the effectiveness of technologies will evolve over time. ArrayComm supports the Commission's effort to consider different ways to measure and increase spectrum efficiency, and utilize technology more efficiently. We urge the FCC to take the first step to develop efficiency targets in the Test-Bed.

Specifically, we encourage the FCC to give careful consideration to the different types of measures related to the efficient use of spectrum. One type is related to the utilization of spectrum by a given application: e.g., the percentage of time that a band is being used in a given geographical area could be considered a measure of spectral utilization. When this is small it may be possible to use technologies that promote opportunistic access to spectral 'white spaces' (e.g., cognitive radios, etc.).

Such situations are likely to be more application-dependent, as opposed to technology-dependent.

An alternate approach is to measure capacity that can be achieved within a given unit of spectrum. It is true that a single metric and a single performance level will not be appropriate for all services. One metric may be required for voice systems, *e.g.,* simultaneous calls/Hz/cell. Another may be required for data services, *e.g.*, bits/second/Hz/cell or bits/second/Hertz/km2. The level of the benefits expected from MAS is very much dependent on the specifics of the radio interface technology.

## Innovation Test-Bed Issues

### Limitations of Shared Spectrum

The challenge in achieving successful shared-spectrum is eliminating the interference that occurs when multiple users simultaneously try to access the spectrum. The Commission's Test-Bed should explore how real world interference problems can be resolved by coordinated spectrum usage and how high-bandwidth technologies can enhance their throughput by utilizing spectral efficient technologies.

MAS works within the constraints placed upon antennas by practical site /zoning considerations, and is relatively independent of antenna type, configuration, or spacing. Although there are different types of sharing scenarios which may or may not be mitigated by different technologies, MAS can be utilized in licensed bands where sharing is related to coexistence with systems operating in adjacent bands or co-channel systems operating in adjacent geographical systems.

Although MAS is not a panacea for all sharing scenarios, MAS is an important element applicable to multiple unlicensed systems sharing the same spectrum in the same geographical area in an uncoordinated manner.

### Requirements

Given the number of complex issues raised in the Commission Notice, ArrayComm believes the Test-Bed should encompass multiple experiments with different requirements. By necessity, a number of different variables and degrees of freedom will need examination, including among other things: Air interface and coding and the impact of interference on spectral efficiency throughput.

### Criteria

As stated in the Public Notice, a minimum of 20 MHz (10 MHz identified by NTIA and 10 MHz identified by the Commission) is suggested for the Test-Bed program. ArrayComm believes that what is most important is that the spectrum utilized in the Test-Bed be coordinated among all users of the spectrum so that the Test-Bed

can control the degree of interference, with enough bandwidth and guard banding to accurately test the selected air interfaces. The study should focus on bands that have the potential for shared use between federal and non-federal users, maximizing the amount of available spectrum for each and taking into consideration the needs of the applications for which they could be made available.

In addition, we urge the Commission to bring together the proponents of TDD and FDD technologies to develop technical and operational regulations. Specifically, ArrayComm recommends that the Test-Bed consider the benefits of Frequency Division Duplex ("FDD") technologies and Time Division Duplex ("TDD") technologies that could enable both technologies to flourish and to provide their particular benefits to federal and non-federal entities. By proposing paired spectrum, (a channel for transmissions from "base stations" and a companion channel for transmissions from "mobiles") FDD systems have been historically more widely used for cellular style systems, principally for reasons stemming from technology limitations that have since been overcome. But advances in semiconductor technology have eliminated these reasons and FDD is no longer optimal for all types of usages. Broadband data solutions and product development today, including solutions based on IEEE 802.16 and 802.11 protocols that are focused primarily on TDD approaches. TDD is better suited to asymmetric applications, e.g., the relaying of situational data from the field or the transmission of Geographic Information Systems data from a fire station to a mobile command post. It is also more amenable to techniques, such as adaptive antennas to improve spectral efficiency. Paired spectrum allocations therefore make some of the most advanced commercial wireless technologies inaccessible to first responders other than as subscribers to some commercial operator's service.

TDD and FDD, in fact, coexist quite effectively in many countries. Coexistence of any diverse technologies, even when they are FDD or TDD can raise compatibility issues and requires careful planning and avoidance techniques. In the past, ArrayComm has also expressed concern about potential problems of coexistence, particularly between wide-area FDD and TDD systems. While ArrayComm focused upon the challenges of FDD/TDD co-existence in adjacent spectrum bands, it has also cautioned that TDD to TDD and FDD to FDD interference can well arise when they attempt to co-exist on adjacent channels in the same geographic area or in the same channel in adjacent geographical areas. While ArrayComm agrees that many coexistence problems can be mitigated, the Test-Bed should promote co-existence and efficient spectrum utilization. ArrayComm is convinced that the Test-Bed will reveal that federal and non-federal can enjoy the benefits of both technologies.

## Test-Bed Resources

The Commission asks commenters to participate in the Test-Beds. Given our current engineering commitments, ArrayComm is unable to devote engineering

resources to the Test-Bed at this time. Given that constraint, ArrayComm looks forward to sharing its expertise and experience, as appropriate, in the future.

Respectfully submitted,
ArrayComm LLC

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